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Kito et al.

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(54) **MECHANICAL SEAL DEVICE**

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CPC ***F16J 15/34*** (2013.01); ***F16J 15/3404*** (2013.01); ***F16J 15/3464*** (2013.01); ***F16J 15/3484*** (2013.01)

(58) **Field of Classification Search**
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See application file for complete search history.

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(57) **ABSTRACT**

In an embodiment, a mechanical seal device has a mating ring (**131**) that rotates with a rotating shaft (**101**), as well as an opposing seal ring (**133**) that slidably contacts the mating ring (**131**), so as to seal between the rotating shaft (**101**) and a seal cover (**105**) fixed to an equipment main body (**102**); wherein the seal cover (**105**) is a split structure comprising at least a first seal cover (**107**, **108**) and second seal cover (**106**), the first seal cover (**107**, **108**) is detachably connected in the axial direction by leaving the second seal cover (**106**)

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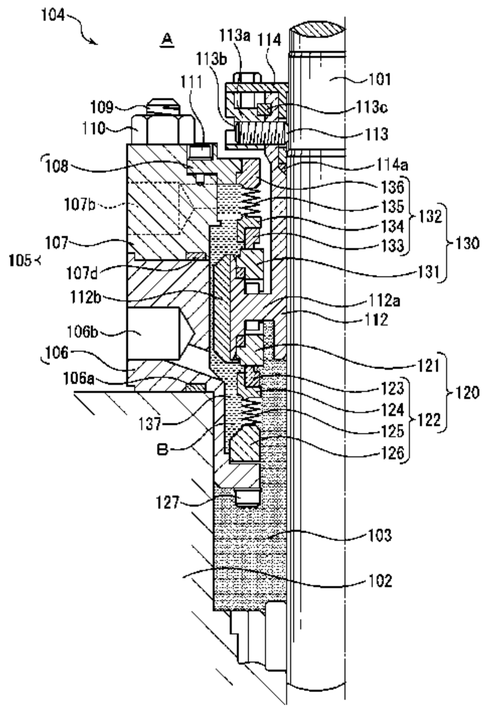

free from it, and the seal ring (**133**) is connected to the first seal cover (**107**, **108**) in a securely following manner.

4 Claims, 3 Drawing Sheets

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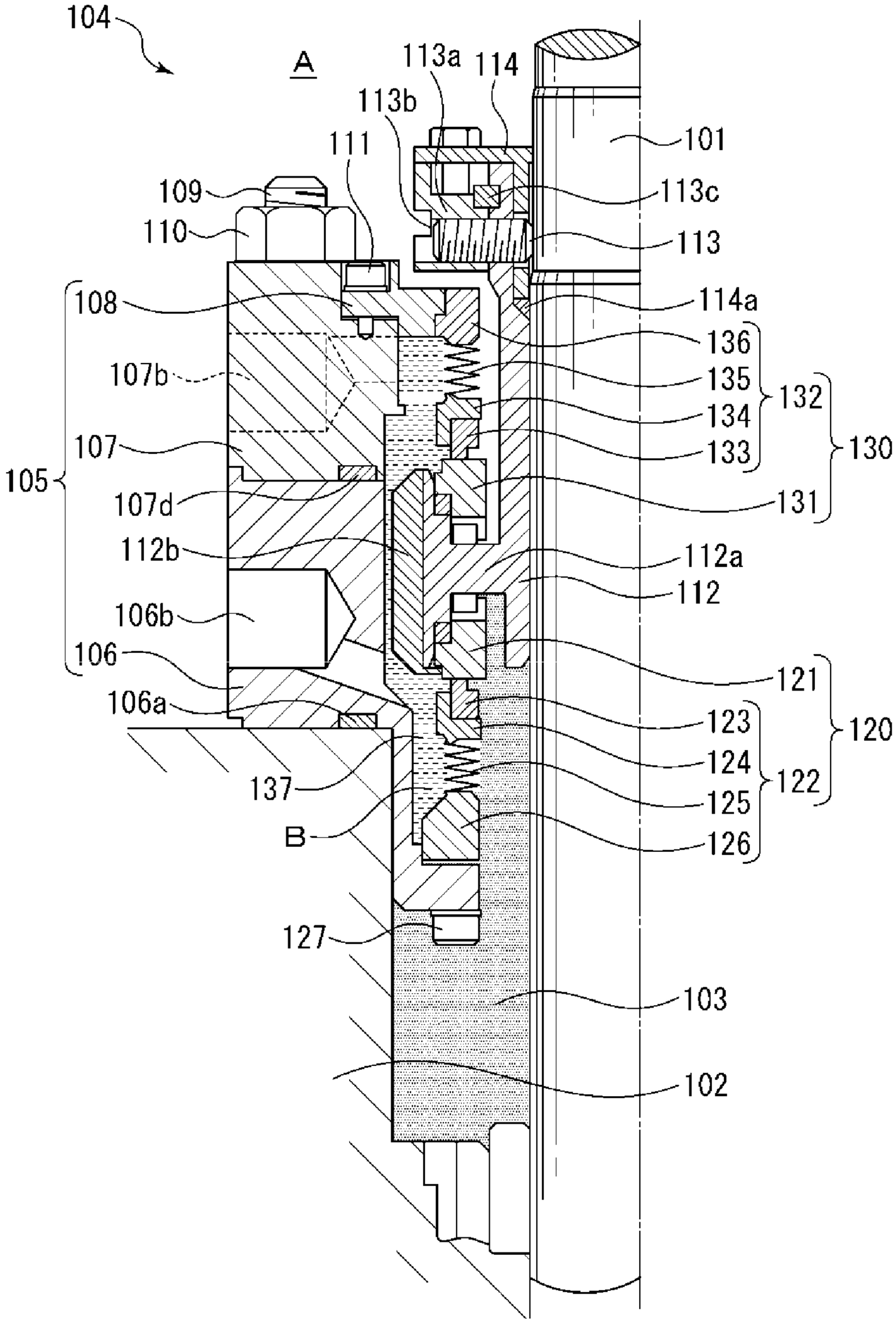
[FIG. 1]


104
A
113a
114
113b
111
101
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113c
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113
108
114a
136
107b
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134
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130
107
133
105
107d
131
112b
112a
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106a
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120
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137
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125
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126
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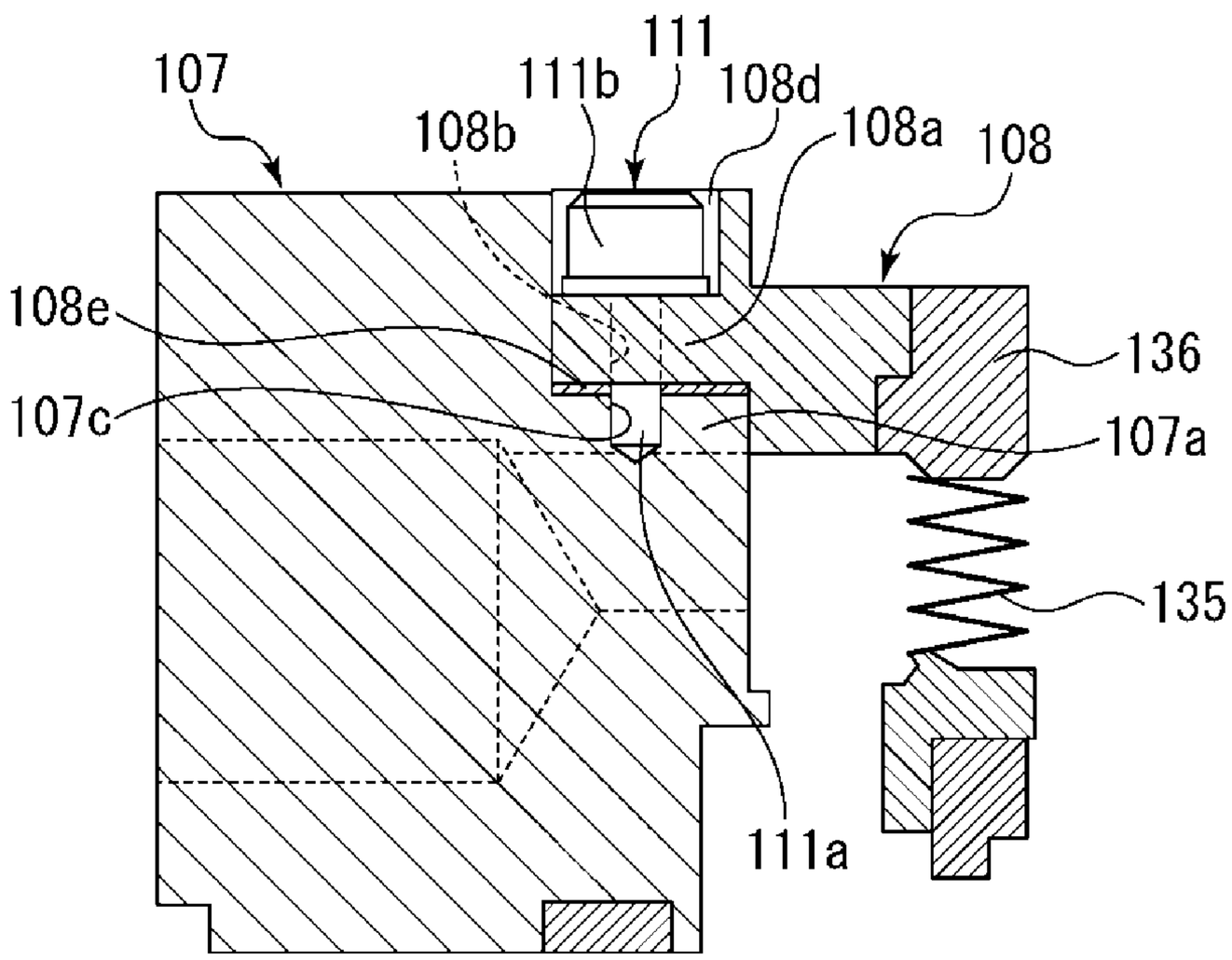
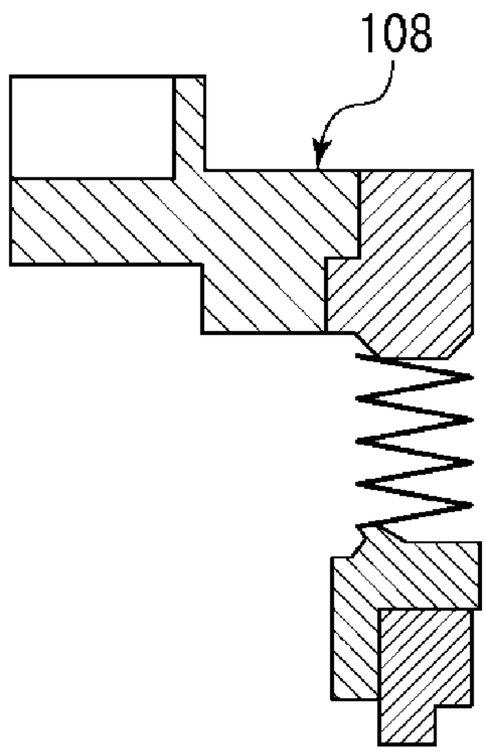
103
102

[FIG. 2]



[FIG. 3]



MECHANICAL SEAL DEVICE

This application is the U.S. National Phase under 35 U.S.C. § 371 of International Application PCT/JP2015/080218, filed Oct. 27, 2015, which claims priority to Japanese Patent Application No. 2014-224146, filed Nov. 4, 2014. The International Application was published under PCT Article 21(2) in a language other than English.

TECHNICAL FIELD

The present invention relates to a mechanical seal device used as an axial seal for rotating equipment in chemical, food, general industry, and other applications.

BACKGROUND ART

A traditional bellows-type mechanical seal device has a seal ring held on a retainer which is fixed to a bellows, and an opposing mating ring that slidably contacts the seal ring, wherein the seal ring is supported on a seal cover via the retainer, bellows, and an adapter, and the mating ring is supported on a rotating shaft and rotates with the rotating shaft (refer to Patent Literature 1, for example).

BACKGROUND ART LITERATURE

Patent Literature

Patent Literature 1: International Patent Laid-open No. 2010/116844 (Paragraph 0016, FIG. 1)

SUMMARY OF THE INVENTION

Problems to be Solved by the Invention

With the mechanical seal device described in Patent Literature 1, the retainer, bellows, adapter, and seal cover constituting the fixed-side seal assembly are fixed to each other by means of welding, etc. Also, the seal cover is fixed to an equipment main body via bolts and nuts. When correcting the sliding contact surface of the seal ring or performing other maintenance, therefore, the bolts and nuts fixing the seal cover to the equipment main body must be unfastened and the fixed-side seal assembly must be removed in the axial direction together with the seal cover before the maintenance can be performed.

However, the seal cover removed at the time of maintenance is structured in such a way that it covers the seal ring or other seal element in the radial direction and axial direction of the rotating shaft and is therefore considerably large in the radial direction and axial direction and heavy, which gives rise to the problem of difficulty handling the seal ring, etc., during maintenance as it is connected to the seal cover via the bellows, etc. This problem is particularly noticeable with mechanical seal devices used for large equipment.

The present invention was conceived from recognizing this problem, and its object is to provide a mechanical seal device with improved seal cover structure that achieves excellent ease of handling the seal ring or other seal element during maintenance.

To achieve the aforementioned object, the mechanical seal device proposed by the present invention has:

a mating ring that rotates with a rotating shaft, as well as an opposing seal ring that slidably contacts the mating ring, so as to seal between the rotating shaft and a seal cover fixed to an equipment main body;

wherein such mechanical seal device is characterized in that the seal cover is a split structure comprising at least a first seal cover and a second seal cover, the first seal cover is detachably connected in the axial direction by leaving the second seal cover free from it, and the seal ring is connected to the first seal cover in a securely following manner.

According to this characteristic, the seal ring is connected to the first seal cover in a securely following manner, and the first seal cover is detachably connected in the axial direction by leaving the second seal cover free from it, so by removing the seal ring from the second seal cover together with the first seal cover, maintenance of the seal ring, etc., can be performed on the connection piece which is lightweight and offers excellent ease of handling.

Another characteristic is that the first seal cover is a split structure comprising an outer-diameter-side seal cover and an inner-diameter-side seal cover, both connected detachably, the seal ring is connected to the inner-diameter-side seal cover in a securely following manner, and a feed hole is provided in the outer-diameter-side seal cover and also in the second seal cover for feeding fluid from the outside into the space where the seal ring is placed.

According to this characteristic, there is no need to form a feed hole in the inner-diameter-side seal cover, which allows for forming the inner-diameter-side seal cover small and lightweight and thereby improving the ease of handling the seal cover during maintenance.

Another characteristic is that the first seal cover is a split structure comprising an outer-diameter-side seal cover and an inner-diameter-side seal cover, the inner-diameter-side seal cover is detachably connected to the outer-diameter-side seal cover from the outer side in the axial direction, and the seal ring is connected to the inner-diameter-side seal cover in a securely following manner.

According to this characteristic, the inner-diameter-side seal cover to which the seal ring is connected can be removed from the outer-diameter-side seal cover without removing the outer-diameter-side seal cover.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** Section view of the mechanical seal device in Example 1.

FIG. **2** Section view of the mechanical seal device in FIG. **1**, showing a state where the first seal cover (outer-diameter-side and inner-diameter-side seal covers) has been removed.

FIG. **3** Section view of the outer-diameter-side seal cover in FIG. **2**, showing a state where the inner-diameter-side seal cover has been removed.

MODE FOR CARRYING OUT THE INVENTION

Modes for carrying out a mechanical seal device pertaining to the present invention are explained below based on examples.

Example 1

The mechanical seal device pertaining to Example 1 is explained by referring to FIGS. **1** to **3**. In the explanations below, the relative directional terms such as "top" and "bottom" refer to those defined in the drawings of FIGS. **1** to **3** and do not necessarily represent the top and bottom of the mechanical seal device after being installed, while the terms "inner side" and "outer side" refer to the sealed fluid side and atmosphere side of the mechanical seal device, respectively.

A mechanical seal device **104** is of the so-called back-to-back double type, where a primary-side mechanical seal **120** and secondary-side mechanical seal **130** are used to axially seal between a rotating shaft **101** extending in the vertical direction and a seal cover **105** enclosing the rotating shaft **101**. A pump impeller housed in an equipment main body **102** is fixed to the bottom of the rotating shaft **101**. The seal cover **105** is fixed to the equipment main body **102** by a bolt **109** and nut **110** and encloses the rotating shaft **101** in the axial direction and radial direction. It should be noted that the space which is formed by the rotating shaft **101** and seal cover **105** and in which the primary-side mechanical seal **120** and secondary-side mechanical seal **130** are placed, is called the "space where the seal ring is placed."

The seal cover **105** is formed by an axial-direction seal cover **106** (second seal cover) which is fixed to the equipment main body **102** with the bolt **109** and nut **110** via a gasket **106***a*, and an outer-diameter-side seal cover **107** (first seal cover) and inner-diameter-side seal cover **108** (first seal cover) which are connected to the end of the axial-direction seal cover **106** and seal in the radial direction. These seal covers **106**, **107**, **108** are each formed as a detachable split structure by stainless steel, aluminum alloy or other metal.

As shown in FIG. **2**, the outer-diameter-side seal cover **107** has a circular cutout at the top on the inner diameter side (end face side on the atmosphere A side), and also has a circular projection **107***a* formed below the cutout and projecting toward the inner diameter side. The inner-diameter-side seal cover **108** has a circular cutout at the bottom on the outer diameter side, and also has a circular projection **108***a* formed above the cutout and projecting toward the outer diameter side, and a counter bore **108***d* to accommodate a head **111***b* of a coupling bolt **111** is formed in the circular projection **108***a*. With a circular gasket **108***e* placed between the side faces of the projections **107***a*, **108***a*, the projection **107***a* of the outer-diameter-side seal cover **107** is aligned in position with the cutout in the inner-diameter-side seal cover and then the coupling bolt **111** is guided from above through a through hole **108***b* provided in the projection **108***a* and through hole in the gasket **108***e* to cause a male thread **111***a* of the coupling bolt **111** to be screwed to a female thread **107***c* of the projection **107***a*, so that the inner-diameter-side seal cover **108** is fixed to the outer-diameter-side seal cover **107** as a result.

The outer-diameter-side seal cover **107** is fixed to the axial-direction seal cover **106** by fastening a bolt (not illustrated). The outer-diameter-side seal cover **107** and axial-direction seal cover **106** are sealed by a gasket **107***d*.

A setscrew **113** screwed with the female thread of a circular sleeve **113***a* fitting to a sleeve **112**, so that the tip of the setscrew **113** abuts the outer periphery surface of the rotating shaft **101** and the sleeve **112** does not rotate but remains fixed. The circular sleeve **113***a* is restrained by a split ring **113***c* from moving outward in the axial direction. A sleeve collar **114** presses a packing **114***a* against the end face of the sleeve **112** to seal along the rotating shaft **101**. The primary-side mechanical seal **120** comprises: a mating ring **121** which is closely fitted and fixed to the bottom of a circular projection **112***a* of the sleeve **112** and rotates with the rotating shaft **101**; a fixed-side seal ring **123** that slidably contacts the mating ring **121**; a retainer **124** that holds the seal ring **123** in place; a bellows **125** which is welded and fixed to the retainer **124** and adds bias force in the axial direction; and an adapter **126** whose one end is welded and fixed to the bellows **125** and other end is fixed by a bolt **127** to the inner periphery of the axial-direction seal cover **106**.

It should be noted that the seal ring **123**, retainer **124**, bellows **125**, and adapter **126** constitute a fixed-side seal assembly **122**.

The secondary-side mechanical seal **130** comprises: a mating ring **131** which is closely fitted and fixed to the top of the circular projection **112***a* of the sleeve **112** and rotates with the rotating shaft **101**; a fixed-side seal ring **133** that slidably contacts the mating ring **131**; a retainer **134** that holds the seal ring **133** in place; a bellows **135** which is welded and fixed to the retainer **134** and adds bias force in the axial direction; and an adapter **136** whose one end is welded and fixed to the bellows **135** and other end is welded and fixed, along its outer periphery, to the inner periphery of the inner-diameter-side seal cover **108**. It should be noted that the seal ring **133**, retainer **134**, bellows **135**, and adapter **136** constitute a fixed-side seal assembly **132**. In other words, the fixed-side seal assembly **132** is connected to the inner-diameter-side seal cover **108** in a securely following manner.

Also, external liquid **137** is sealed in an interim chamber B between the primary-side mechanical seal **120** and secondary-side mechanical seal **130**, filling the chamber to its top. Provided downward of the axial-direction seal cover **106** is an inlet hole **106***b* (feed hole) which connects to the interim chamber B housing the primary-side mechanical seal **120** and through which the external liquid **137** flows in from the outside, while provided roughly at the center of the outer-diameter-side seal cover **107** in the vertical direction is an outlet hole **107***b* (feed hole) which connects to the interim chamber B housing the secondary-side mechanical seal **130** and through which the external liquid **137** flows out to the outside, and the external liquid **137** keeps the interim chamber B at a desired pressure. Also, the external liquid **137** is circulated by an impeller **112***b* provided on the sleeve **112**.

Next, maintenance of the seal ring **133**, etc., is explained.
(Step 1) As a preparation, a liquid or gas **103** in the pump chamber is drained and the external liquid **137** in the interim chamber B is drained from a drain port (not illustrated). With a set plate (not illustrated) engaging with a concave part **113***b* of the circular sleeve **113***a*, the set plate is installed to the outer-diameter-side seal cover **107** by a set plate bolt (not illustrated), after which the setscrew **113** and nut **110** are removed and the mechanical seal device **104** is removed from the equipment main body **102**.

It should be noted that, by installing the set plate, the outer-diameter-side seal cover **107** is fixed to the sleeve **112** via the circular sleeve **113***a* and split ring **113***c*, and the primary-side mechanical seal **120** and secondary-side mechanical seal **130** can now be assembled into a cartridge structure having the same mode for use as that shown in FIG. **1**.
(Step 2) The set plate bolt is loosened and the set plate is removed, and the split ring **113***c* and sleeve collar **114** are removed, as well.
(Step 3) The coupling bolt **111** is loosened and the outer-diameter-side seal cover **107** is removed from the inner-diameter-side seal cover **108**. FIG. **3** shows the state after the seal cover has been removed.
(Step 4) Maintenance of the fixed-side seal assembly **132** is performed, such as repairing the seal ring **133**.
(Step 5) The dismantling steps defined in Steps 1 to 4 above are performed in the reverse order to restore the original state.

Because the seal ring **133** is connected to the inner-diameter-side seal cover **108** (first seal cover) in a securely following manner, and also because the inner-diameter-side

seal cover **108** (first seal cover) and outer-diameter-side seal cover **107** (first seal cover) are detachably connected in the axial direction by leaving the axial-direction seal cover (second seal cover) free from them, as described above, the assembly shown in FIG. **2** can be obtained by removing the seal ring **133**, inner-diameter-side seal cover **108** (first seal cover) and outer-diameter-side seal cover **107** (first seal cover) from the axial-direction seal cover **106** (second seal cover), which allows for maintenance of the seal ring **133** on the connection piece which is lightweight and offers excellent ease of handling.

Furthermore, because the inner-diameter-side seal cover **108** is detachably fixed to the outer-diameter-side seal cover **107**, the outer-diameter-side seal cover **107** can be removed from the assembly shown in FIG. **2** if a need arises to replace the fixed-side seal assembly **132**, and since there is no need to replace the outer-diameter-side seal cover **107** and all that is needed is to replace the fixed-side seal assembly **132** and inner-diameter-side seal cover **108**, excellent economy is achieved.

Additionally, because the outer-diameter-side seal cover **107** is detachably connected to the axial-direction seal cover **106**, there are more options during maintenance because it is possible to remove the inner-diameter-side seal cover **108** after it has been removed from the axial-direction seal cover **106** together with the outer-diameter-side seal cover **107**, or remove the inner-diameter-side seal cover **108** without removing the outer-diameter-side seal cover **107** from the axial-direction seal cover **106**.

Also, the inner-diameter-side seal cover **108** has no feed hole for external liquid or other fluid and the outlet hole **107***b* is provided in the outer-diameter-side seal cover **107** extending to the top, which increases the degree of flexibility of placing the outlet hole **107***b*. When a longitudinal pump is used, the outlet hole **107***b* can be placed even higher to keep gas from collecting above the interim chamber B.

Furthermore, as another maintenance procedure, because a circular projection **108***a* of the inner-diameter-side seal cover **108** is provided above (on the atmosphere A side of) a circular projection **107***a* of the outer-diameter-side seal cover **107**, the inner-diameter-side seal cover **108** and fixed-side seal assembly **132** can be removed simply by loosening the coupling bolt **111** without loosening the nut **110**, or specifically with the outer-diameter-side seal cover **107** still fixed to the axial-direction seal cover **106**.

The foregoing explained the examples of the present invention using the drawings; however, specific constitutions are not limited to these examples and other modifications and additions are also included in the scope of the present invention so long as they do not deviate from the main points of the present invention.

For example, the foregoing explained a fixed-side seal assembly having a seal ring, retainer, bellows, and adapter; however, any fixed-side seal assembly may be used so long as it has at least a seal ring. In other words, any fixed-side seal assembly may be used so long as a seal ring is connected to its inner-diameter-side seal cover.

In addition, while desirably the outer-diameter-side seal cover **107** is made of stainless steel known for its excellent rigidity and corrosion resistance, the inner-diameter-side seal cover **108** can have relatively lower rigidity and therefore it suffices that this seal cover is constituted by a material offering excellent corrosion resistance, such as a resin molding or a metal other than stainless steel with corrosion-resistant coating applied to it.

Also, while the foregoing explained mechanical seal devices of the tandem type and double type, other types of mechanical seal devices are also supported.

DESCRIPTION OF THE SYMBOLS

101 Rotating shaft
102 Equipment main body
104 Mechanical seal device
105 Seal cover
106 Axial-direction seal cover (second seal cover)
106*b* Inlet hole (feed hole)
107 Outer-diameter-side seal cover (first seal cover)
107*a* Circular projection
107*b* Outlet hole (feed hole)
108 Inner-diameter-side seal cover (first seal cover)
108*a* Circular projection
111 Coupling bolt
111*b* Head
120 Primary-side mechanical seal
121 Mating ring
122 Fixed-side seal assembly
123 Seal ring
125 Bellows
130 Secondary-side mechanical seal
131 Mating ring
132 Fixed-side seal assembly
133 Seal ring
135 Bellows

What is claimed is:

1. A mechanical seal device comprising a seal cover fixed to a stationary body of an apparatus provided with a rotating shaft, a first mechanical seal having a first mating ring configured to rotate with the rotating shaft, as well as a first seal ring configured to slidably contact the first mating ring, and a second mechanical seal having a second mating ring configured to rotate with the rotating shaft, as well as a second seal ring configured to slidably contact the second mating ring,

wherein the first mechanical seal and the second mechanical seal are configured in contact with a sealed fluid and an atmosphere, respectively, and are configured to seal the fluid between the rotating shaft and the seal cover;

the seal cover being a split structure comprising at least a first seal cover and a second seal cover detachably connected to each other in an axial direction,

the first seal cover being a split structure comprising at least an outer-diameter-side seal cover and an inner-diameter-side seal cover, the inner-diameter-side seal cover being detachably connected to the outer-diameter-side seal cover from an outer side in the axial direction,

the first seal ring being connected to the second seal cover,

the second seal ring being connected to the inner-diameter-side seal cover in a securely following manner,

the mechanical seal device further comprising a sleeve fixed to the rotating shaft and having a circular projection protruded in an outward radial direction, the circular projection having a first side part on a side of the sealed fluid and a second side part on the atmosphere side which are opposed to each other in an axial direction, and

a backside part of the first mating ring and a backside part of the second mating ring being fixed to the first side part of the circular projection and the second side part of the circular projection, respectively.

2. A mechanical seal device according to claim 1, wherein the outer-diameter-side seal cover and the second seal cover are configured to partially define a space where the first and second seal rings are placed, and wherein an inlet hole and an outlet hole are provided in the second seal cover and the outer diameter-side seal cover, respectively, for feeding an external fluid from outside into the space.

3. A mechanical seal device according to claim 1, wherein the second seal ring is held by a retainer, the inner-side seal cover being fixed to an adapter by welding, the retainer being fixed to a first end of a bellows by welding, and a second end of the bellows being fixed to the adapter by welding.

4. A mechanical seal device according to claim 1, further comprising an impeller provided on a top of the circular projection of the sleeve and configured to circulate the external fluid in the space.

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